PATENT

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NDB 4-28-03

Application No.:	09/977,552
Filing Date:	10-15-2001
Applicant:	Hank Millet et al.
Group Art Unit:	3746
Examiner:	Emmanuel Sayoc
Title:	COMPRESSOR WITH CONTROL AND PROTECTION SYSTEM
Attorney Docket:	0315-000487/DVA

Commissioner of Patents and Trademarks
Washington, D.C. 20231

DECLARATION UNDER 37 C.F.R. §1.131

Sir:

Hank E. Millet, Natarajan Rajendran and William W. McCroskey hereby declare:

1. That we are the inventors who, on October 15, 2001, filed the above-identified application claiming priority to Application Serial No. 09/515,802, filed February 29, 2000, now Patent No. 6,302,654.

2. That we conceived our invention in this country prior to October 28, 1997, the 35 U.S.C. §102(e) date that United States Patent No. 6,471,486 to Centers et al. is available as a reference.

3. That our invention conception in the United States prior to October 28, 1997, is evidenced by the GPM Technology Report documenting our invention. A photocopy of the relevant portion of GPM Technology Report is attached hereto.

4. That we were diligent from prior to October 28, 1997 to a subsequent reduction to practice or to the filing of the patent application.

5. That each of the dates deleted or otherwise blacked out from the attached report is prior to October 28, 1997. Other deleted and/or blacked out portions protect confidentiality or are irrelevant.

6. That we have never abandoned our application.

7. We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 the United States Code, and that such willful false statement may jeopardize the validity of the application, and patent issuing thereon, or any patent to which this verified statement is directed.

Date: March 31, 2003 — Hank E. Millet

Date: 3/31/03 — Natarajan Rajendran

Date: 3/23/2003 — William W. McCroskey

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Report AS7-10383
GPM Technology

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7. **Advanced Compressor Control and Protection System**

Between the time of the development of GPM-1 and the present, a prototype control utilizing a Motorola 3150 processor was designed and built that incorporated all of the features identified for a GPM in the original plan. The sensor development work described above was also performed during this time period. Since technology continued to be developed that enabled the more advanced GPM-3, The specifications for the "GPM-2" product was rewritten to include the entire feature set. And since the GPM series is actually applicable to HVAC as well as refrigeration, and applies to all compressor families used in vapor compression system in general, the name of the project was changed to ACCPS for Advanced Compressor Control and Protection System to distinguish it from traditional compressor modules.

What is ACCPS? ACCPS incorporates sensing, protection, and control functions not provided by the traditional motor protection modules in use today. It integrates these functions with the compressor for improved overall system cost, reliability and value, and provides improved compressor protection, simpler system wiring, diagnostics, and communications. ACCPS provides a common hardware platform for a broad range of copeland's compressor models.

Significant features of ACCPS include:

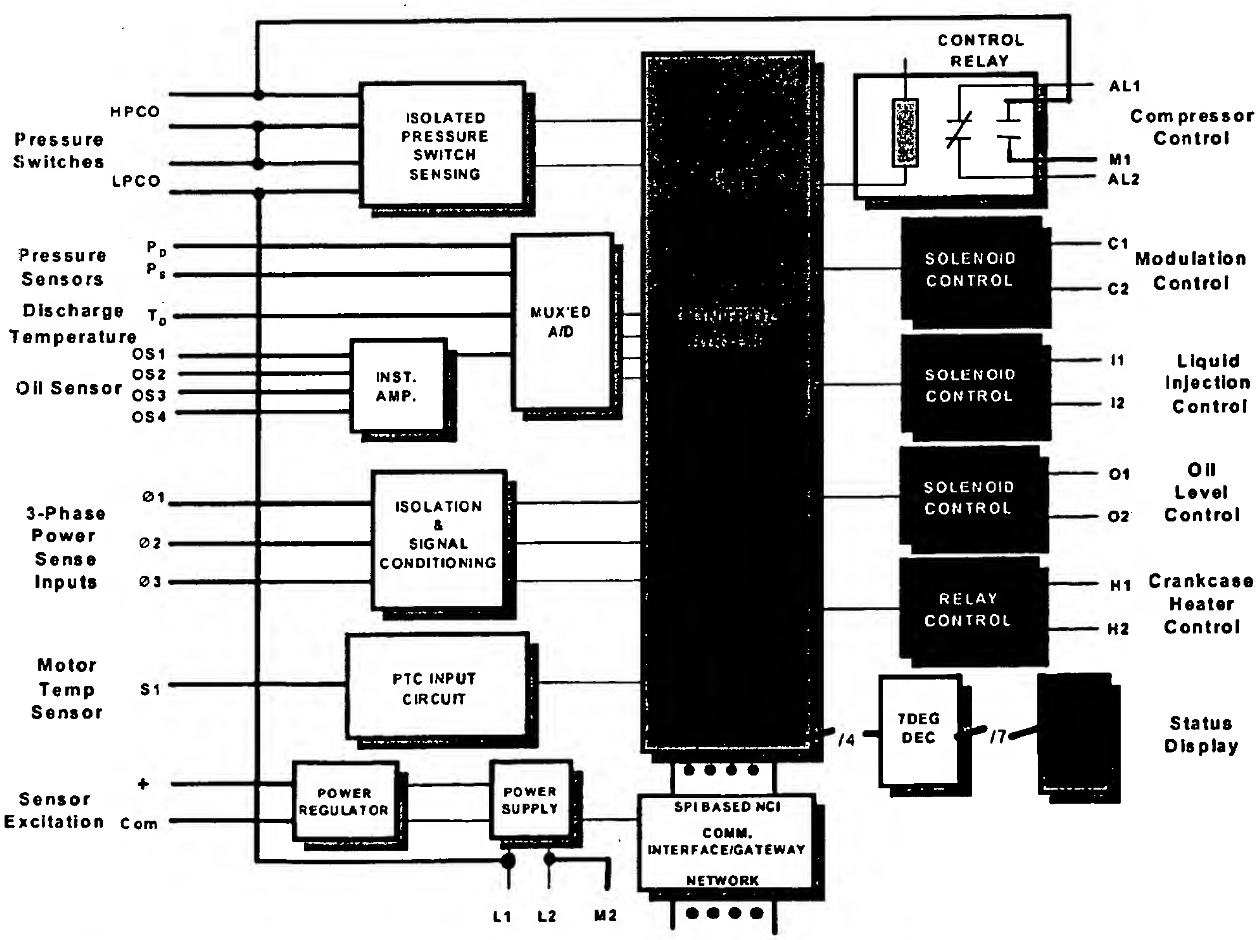
- Network Communications
- Direct Compressor Contactor Control
- Integrated Packaging, Terminal Box Is Now the Control Housing
- Board Pluggable Options Including:
    - Network Communications Gatway
    - Liquid Injection Control
    - Oil Level Control
    - Modulation Unloader Control/Solenoid Drive

[redacted]

- Crankcase Heater Control
- Pressure Sensors

- Compressor Status Display Using Single, Easy-To-Read Alpha-Numeric Character
- Pressure Switches Monitored By Compressor Control
- Oil-Level Sensing Integrated With Compressor
    - No Moving Parts Or Mechanical Switches
    - No Flanges, Adapters Or O-Rings
- Available Suction Pressure Control (LPCO)
- Direct Compressor Contactor Control Through Comm. Port

The block diagram below illustrated the major functional elements of the ACCPS. The block labeled CONTROL BLOCK can be implemented with a microcontroller or DSP and contains the firmware for implementation of the measurement, control, diagnostic/protection, and network communications functions of the ACCPS.



8. Communications

network?

The data communications protocol for ACCPS is designed for low-cost implementation of distributed control networks in commercial HVAC and Refrigeration applications. It is designed to be implemented globally in advanced system components making them communications ready. A low-cost interface is used thus placing a minimum cost burden on applications not requiring communications.

interface

The lowest cost interface uses the widely available SPI protocol introduced by Motorola Semiconductor. It was designed to allow communications between a microcontroller and IC's on the board providing expanded peripheral functions. Another bus, the I^2C is similar and was developed by Signetics/Philips Semiconductor. By using these buses, the only hardware required for connection to a pluggable gateway board is a suitable connector. By taking this approach, the system communications protocol is limited only by the gateways made available.

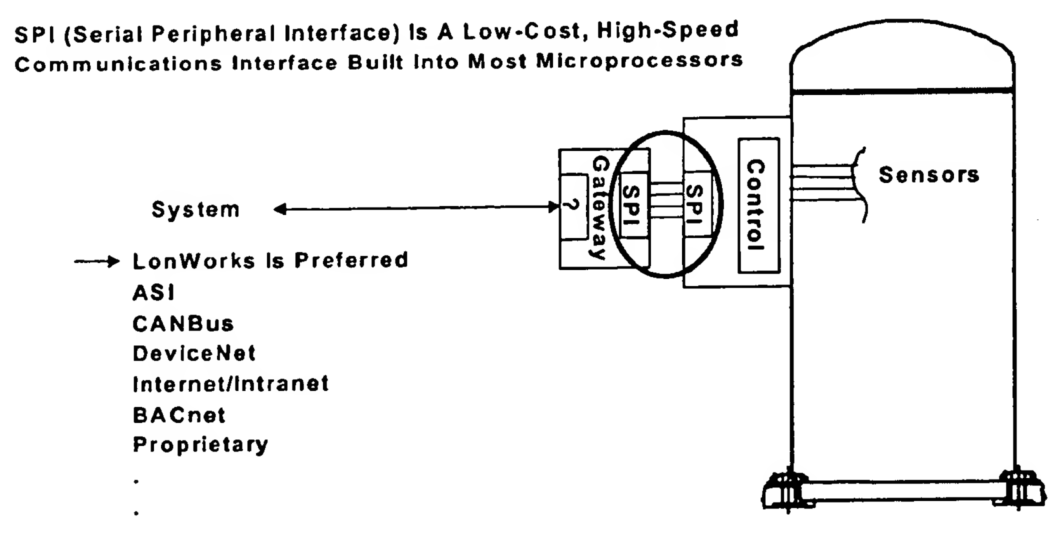
gateway

Although the SPI and I^2C are probably the lowest cost approaches to providing communications even where it is not desired by the customer, an adapter or gateway is required for communications in all cases where it is needed. If a serial interface using RS-485 is provided as standard, local serial bus communications is possible without added electronics. This would be a good implementation choice where the additional cost is not an issue.

protocol

The protocol used by ACCPS for either the simple SPI-to-gateway communications or in the case of an RS-485 based local network application is designed specifically for this optional, multi-protocol approach. It is a master-slave protocol. The system control is the master when the local RS-485 interface is used. If another protocol is required, the gateway module acts as the master on the compressor control interface side.

The figure below illustrates the SPI interface concept



Details of the message structure are below.

[redacted]

Byte 0		Byte 1		Bytes 2 – *N*-1	Byte *N*
Node Address	Message Type	Packet Number	Packet Length	Data Packet	Checksum
5 Bits (0-31)	3 Bits (0-7)	3 Bits (0-7)	5 Bits (0 – 31)	0-31 Bytes	8 Bits

Node Address Assignments

There are 32 node addresses to specify the target node. Address 0 is reserved for master broadcast messages. Address 31 is reserved for messages to the bus master. The remaining addresses are available for slave nodes.

The Node Address is contained in the 5 most significant bits of Byte 0

Message Types

The message type is contained in the least significant 3 bits of Byte 0. Eight message types are defined as follows:

1. Slave Status Request

This message is used by the system master to interrogate a slave node for its status. The addressed slave responds with one or more Status Reply messages. This message has a packet length of zero (0).

2. Status Reply

This message is used by slave nodes as a reply to Slave Status Request messages from the system master.

3. Control Command

A Control Command message is used to control the actuator outputs of a slave node. Packet zero (0) of this message type is always a single byte and is used as a hardware reset command. All bits set to 1's generates a hardware reset in the slave node.

4. Configuration Request

[redacted]

The Configuration Read message is used by the system master to command a slave node to send its configuration data by means of one or more data packets contained in Configuration Data messages. This message has a packet length of zero (0).

5. Configuration Data

The Configuration Data message is used to send data packets containing the slave node's configuration data when the slave node has received a Configuration Read message. This is typically data stored in the slave node's EEROM or Flash Memory storage. It can be information which identifies the node type, serial number, date of manufacture, event histories etc.

6. Sensor Read Request

The Sensor Read message is sent by the system master to command the slave node to send its sensor data. This message has a packet length of zero (0).

7. Sensor Data

This message type is sent by a slave node in response to the Sensor Read message from the system master.

8. Receipt Response

The Receipt Response message is sent by a slave node in response to messages from the system master which do not require data to be returned. The data packet is always a 1 byte ACK or NAK.

Packet Number

A message type may have up to 8 packets. Each packet may be 1 to 32 bytes in length and is sent in a separate message. The first message sent has the packet number set to the number of packets to be sent. Each subsequent message has the packet number decrememted. The last message contains the last packet to be sent and is packet number zero (0).

The Packet Number is contained in the most significant 3 bits of Byte 1.

Packet Length

The Packet Length specifies the length of the Data Packet in each message. The Packet Length is contained in the least significant 5 bits of Byte 1

Data Packet

[redacted]

Each message contains a data packet with up to 31 data bytes. The only exception is a packet length of zero (0) bytes. In this case there is no data packet in the message.

Node Types

Node definitions can be created for any component in a system that is capable of supporting communications. A good example would be a refrigeration case control. Or if partitioning of the system is desired, node definitions for individual or groups of sensors and actuators would make sense. These definitions would define the specific messages and their content as required for the particular device(s) This document release focuses on the compressor node only.

Compressor Node

The compressor node utilizes all messages types available. The Configuration Data message type 5 is used to transfer the compressor configuration data between the system master and each compressor node. The compressor is shipped with the data preconfigured. The system master may send a Configuration Request to a selected compressor node and get an image of the stored data. It may modify that data or it may construct a completely new image and sent it the compressor for storage by sending it in the appropriate series of Configuration Data packets. Typical configuration variables are listed below

Configuration Data List

<u>Compressor Information</u>

Compressor Model Code
Compressor Serial Number
Application
Application Temperature Range
Refrigerant Code
Oil Code
Oil Charge

<u>Customer Information</u>

Customer Name
Customer Model Number

<u>Control Configuration</u>

Anti Short Cycle Time
Discharge Pressure Cut-in
Discharge Pressure Cut-out
Discharge Pressure Sensor Option Enabled
Discharge Trip Time
Discharge Multiplier
Discharge Divider

[redacted]

Oil Add Set Point
Oil Stop Add Set Point
Oil Trip Set Point
Oil On Time
Oil Off Time
Oil Add Period
Shake Limit (pulses/10 second period.)
Shake Count (number of periods)
Suction Pressure Low Limit
Suction Pressure High Limit
Suction Multiplier
Suction Divider
Suction Pressure Sensor Option

Additional information in the Configuration Data category is certain history information as listed below.

Event History

Compressor Cycles
Compressor On Time
Discharge Pressure Trips
Motor Trips
Oil Trips
Suction Pressure Limit Trips
Shake Limit Trips
Events Since Cleared (Last 8?)

Some typical Sensor Data which would be sent in response to a Sensor Data Request would be as below.

Anti Short Cycle Time – 32 bit unsigned (mS)
Discharge Pressure Cut-in – 32 bit signed (up to 6553.5 kPa, res. 0.1 kPa)
Discharge Pressure Cut-out – 32 bit signed (up to 6553.5 kPa, res. 0.1 kPa)
Discharge Trip Time – 16 bit unsigned (res. 0.01 S)
Discharge Multiplier – 32 bit unsigned
Discharge Divider – 32 bit unsigned
Suction Pressure Cut-in – 32 bit signed (+,- 3276.7 kPa, res. 0.1 kPa)
Oil Stop Add – 16 bit unsigned
Suction Pressure Cut-out – 32 bit signed (+,- 3276.7 kPa, res. 0.1 kPa)
Suction Multiplier – 32 bit unsigned
Suction Divider – 32 bit unsigned
Oil Add – 16 bit unsigned
Oil Trip – 16 bit unsigned
Oil On Time – 32 bit unsigned (mS)

[redacted]

Oil Off Time – 32 bit unsigned (mS)
Oil Add Period – 16 bit unsigned (0.01 S)
Vibration Limit – 16 bit unsigned – pulses / 10s
Vibration Count – 8 bit unsigned – 10s periods

[redacted]